The social feasibility of road pricing. A case study for the Randstad area

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The Social Feasibility of Road Pricing

A Case Study for the Randstad Area

Erik T. Verhoef, Peter Nijkamp and Piet Rietveld*

1. Introduction

Road pricing[1] is a highly controversial topic, and debates about its desirability tend to be heated. Economists often seem surprised by the difficulties they face in communicating this 'obviously good idea', and apparently have done an unsuccessful job so far in convincing politicians and the public at large of the beneficial properties of road charging (Arnott *et al.*, 1994). Moreover, even academics themselves appear to have strong and passionate but diverging opinions on the issues of road congestion and congestion charging, as shown by the relatively large number of comments and replies that papers on these topics seem to trigger (Foster, 1974, 1975 *versus* Richardson, 1974, 1975; Else, 1981, 1982 *versus* Nash, 1982; Evans, 1992, 1993 *versus* Hills, 1993; and Lave, 1994, 1995 *versus* Verhoef, 1995).

The apparently limited social and political feasibility of road pricing has led various authors to study this problem from different perspectives. However, empirical research into this important issue is scarce. Nevertheless, it is evident that, no matter how important theoretical reasoning may be for understanding the pros and cons of road pricing, its feasibility will in the end be an empirical matter. This paper discusses the outcomes of a survey among morning peak road users in the Dutch Randstad area, the main aim of which was to provide an exploratory analysis of road users' opinions on road pricing.

The paper starts with a brief review of the problem of road pricing's limited social feasibility. The study design and some general results are presented in Section 3. The exploratory analysis of the opinions on road pricing in Section 4 is ordered according to the structure of the recursive model that was designed for this purpose. Section 5 considers the allocation of revenues, and its impact on the feasibility of road pricing. Finally, Section 6 presents conclusions.

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[1] The term "road pricing" usually refers to congestion pricing in the literature. This paper also concentrates on congestion pricing; road charges for environmental externalities are not explicitly considered.

2. A Review of the Feasibility of Road Pricing

The simplest economic analysis of the social feasibility of road pricing assumes users of a congested road who are, apart from their marginal willingness to pay for making a trip, identical in all other respects (in particular, income and value of time). Although the optimal congestion tax in such a situation yields a *potential Pareto improvement* by increasing social welfare, everybody, except the regulator, is made worse off by road pricing if the optimal tax revenues are not somehow redistributed. Those who continue using the road incur (equal) net welfare losses because the optimal tax is necessarily higher than the value of the realised time gains (unless demand is completely elastic). Those who are taxed off the road incur welfare losses varying between the welfare losses incurred by those who continue using the road (for the marginal 'non-user' after road pricing) and 0 (for the initial marginal user). Therefore, those who are taxed off the road generally incur smaller welfare losses than those who continue using it — otherwise, the former would of course also continue using it. Various authors have observed that these redistributional effects of road pricing may dominate the efficiency gains (Segal and Steinmeier, 1980; Borins, 1988; and Evans, 1992).

A well established result from the literature, however, is that some road users may actually benefit from road pricing when heterogeneity of road users is allowed for. The typical case considered concerns income differences. Starting with Richardson (1974), most authors conclude that road pricing is likely to be regressive (Layard, 1977; Glazer, 1981; Niskanen, 1987; Arnott *et al.*, 1994[2]).[3] Clearly, stated this way, the non-intervention outcome is taken as a reference. Another way of looking at it is that higher income drivers suffer disproportionally from unregulated (excessive) congestion. From that perspective, it is of course questionable whether the progressive incidence of welfare losses from unregulated congestion provides a sound basis for leaving this inefficiency in existence.

The regressive impact of road pricing can be illustrated by noting that an individual's willingness to pay for marginal changes in travel time (t) can be written as:

$$\frac{dV}{dt} = \frac{-U_t}{U_M} = \frac{U_T}{U_M} \tag{1}$$

where V is the individual's valuation of total travel time t (hence, V is a cost); U_t denotes the marginal utility of travel time and U_T the marginal utility of time; and U_M denotes the marginal utility of income. U_M is therefore identical to the Lagrangian multiplier associated with the standard consumer's optimisation problem $MAX_x U(x)$ s.t. $M-px \geq 0$ (where U denotes utility, x the bundle of goods consumed, M the budget and p the vector of market prices), and hence represents the marginal utility of income (or money); see Verhoef *et al.* (1996a). The left-hand side gives the individual's marginal value of time on the road, or the willingness to pay for time savings on the road network. As is clear from equation (1), this willingness to pay is positively related to the marginal utility of time – $U_t = U_T$, and inversely related to the marginal utility of income U_M. On the micro level, then,

[2] In addition, Arnott *et al.* (1994) conclude that a toll is likely to benefit drivers with relatively high scheduling costs.

[3] Foster (1974, 1975), in contrast, stresses that road pricing can be progressive, in particular when society is divided into "rich" car owners and a "poor" others group.

one would expect the congestion toll to be beneficial, if for anybody, for those with a relatively high marginal utility of time and a relatively low marginal utility of income. The latter effect directly causes road pricing to be regressive.

Giuliano (1992) notes that such equity considerations may merely "present an apparently legitimate basis for opposition that is actually motivated by other reasons" (p. 349), and Small (1983, 1992a) stresses at several points that road pricing may actually be progressive given certain redistributions of revenues. Nevertheless, the income transfers due to road pricing have played an important role in the discussion of its feasibility (Evans, 1992). Various authors have proposed schemes of spending the funds raised by road pricing in such a way that as many actors as possible eventually benefit, so that the opposition will be minimised (Goodwin, 1989; Jones, 1991; Small, 1992a). Daganzo (1995) approaches the issue from the other side, by proposing a combination of rationing and pricing that reduces the size of money transfers. Else (1986) mentions the possibility of leaving road users a choice between paying a toll or queuing (see also Verhoef *et al.*, 1996b). Others (Starkie, 1986; Poole, 1992; May, 1992) concentrate on various other aspects of road pricing, especially those related to its introduction, that may help to improve its public acceptability.

Notwithstanding the importance of the topic, and in spite of the impressive list of theoretical contributions (see Emmerink *et al.*, 1995, for a review), empirical research on the social feasibility of road pricing is scarce. Segal and Steinmeier (1980) and Small (1983, 1992a) use empirical bases for their simulation studies towards the distributive impacts of road pricing. Seale (1993) investigates London politicians' attitudes towards road pricing and finds, for instance, that there is a positive correlation between knowledge of the concept, and the support for road pricing. Also for London, Sheldon *et al.* (1993) report the results of an interview study among London residents. Some main conclusions are that road pricing is more likely to be accepted if the system is simple, if enforcement is guaranteed, and when the revenues are used in a transparent and equitable manner. The authors are not aware of any other empirical material on this topic. It is evident, however, that with road pricing back on the political agenda at various places (see, for instance, Small and Gomez-Ibañez, 1996), the importance of empirical investigation into this issue can hardly be overestimated. This was the reason for undertaking the present research.

3. Study Design and Some General Results

Over recent decades, road charging has frequently been proposed as a means of reducing road mobility in The Netherlands, especially in the Randstad area. This is the dense, central area including the relatively close cities of Amsterdam, Den Haag (The Hague), Rotterdam and Utrecht. At the time that the survey was held (June 1995, before summer holidays), road pricing had just been discussed in the Dutch Parliament again, and a large proportion of Dutch road users in the Randstad can therefore be expected to be familiar, to some extent, with the concept of road charging, and with the possibility of its future introduction. This may partly explain the relatively high response rate (40 per cent) to the

questionnaire. It would take too long to discuss the questionnaire itself in great detail here; the Appendix gives an impression of the questions asked. The questionnaires were distributed among morning peak road users at nine filling stations in the Randstad area between 7 and 10 a.m.

The key variable to be analysed in the following sections concerns the morning peak road users' opinions on road pricing. The following opinions could be ticked on the questionnaire: "no opinion"; "bad idea"; "moderate idea"; "of course I do not feel like paying road charges, but nevertheless I think it is a good idea"; and "good idea". Almost 50 per cent of the sample find road pricing a bad idea; increasingly positive judgements are given by descending numbers of respondents. About 25 per cent consider road pricing a good idea, albeit that most of these respondents admit that they are not keen on paying for morning peak road use. Although the general picture of the social feasibility of road pricing that emerges from these figures is not too optimistic, it should be noted that, at least, this picture is more optimistic than the conclusion implied by the most basic model.

4. An Exploratory Recursive Analysis of Morning Peak Road Users' Opinions on Road Pricing

4.1 The recursive model

One of the main aims of the survey was to explore the factors that determine the respondents' opinions on road pricing. The analysis thus gives an idea of which groups will be more opposed to road pricing, should it be implemented. The outcomes of the study may therefore help governments in formulating supplementary policies that could improve the social feasibility of road pricing.

Subsection 4.5 discusses an ordered probit estimation of the factors explaining the opinions on road pricing. Such an analysis has the disadvantage that only the direct impacts of various individual characteristics on the opinion can be assessed. However, it is important to see whether some variables may also, or perhaps only, have an indirect impact. The recursive model as depicted in Figure 1 was constructed to check for such indirect effects, and thus to assess the most important dependencies between the explanatory variables for the respondents' opinions on road pricing.

Working backwards through Figure 1, the following general model structure is assumed. First, apart from a number of exogenous variables (income, education, and so on), the opinion on road pricing may depend on the considered alternatives for current behaviour if a road price becomes prohibitively high for the individual. This reflects the fact that respondents who have relatively close alternatives (trip rescheduling, or relatively attractive public transport) may be less opposed to road pricing than, for instance, those who have reported that they have no alternative for their current behaviour in the morning peak. Next, the 'classical' variable of willingness to pay (WTP) for time gains is included. Finally, various measures for the disutility of congestion are considered. Apart from the (marginal) disutility of time losses, which should in theory be captured in

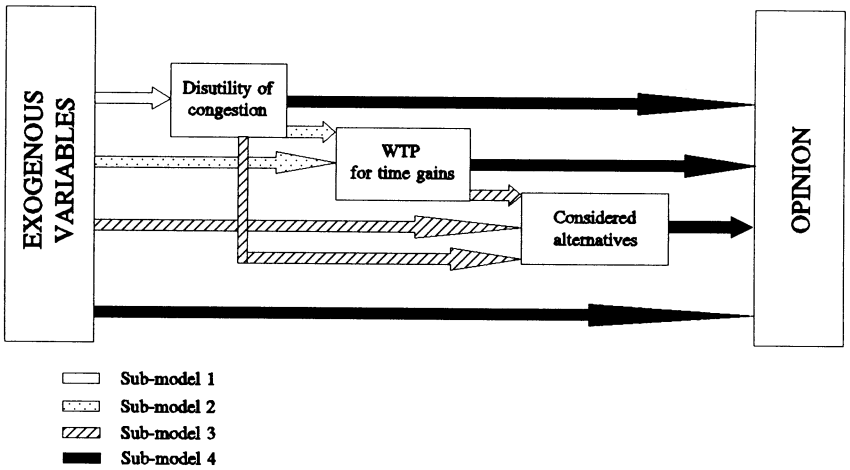

Figure 1
The Full Recursive Model of Peak-Hour Road Users' Opinions on Road Pricing

the WTP for time gains (see equation (1)), the disutility resulting from uncertainty, unpleasant driving conditions, and also the extent to which the respondent finds congestion a general social problem, may directly affect the opinion on road pricing. Sub-model 3 investigates whether the reported alternatives to road use depend on a number of exogenous variables, on the WTP for time savings, and on the weights attached to the various inconveniences of congestion. Sub-model 2 is estimated to see whether the WTP for time gains indeed depends on income and disutility of time losses as implied by equation (1), and if it also varies across individuals according to other characteristics. In this estimation, U_t in equation (1) will be broadened from time losses only, to include other inconveniences of congestion (uncertainty, driving conditions) as well. Finally, sub-model 1 is estimated to see whether particular groups attach different weights to various inconveniences which result from road traffic congestion.

Before turning to the results, it should be mentioned here that the Appendix contains a list of variables, with their definitions, the abbreviations used below, and — for dummy variables — the reference groups considered.

4.2 The disutility of congestion

The logical start for the analysis of the social feasibility of road pricing is to assess the extent to which, and the reasons why, road users dislike congestion. A number of questions were related to these matters, and the answers can be used as first proxies for the marginal disutility of congestion, $-U_t$ in equation (1).

As far as driving in congested situations is concerned, only 2.6 per cent of the respondents have no opinion or do not dislike driving in congestion. The others have a moderate (25.0 per cent), clear (41.2 per cent) or strong (31.1 per cent) dislike of driving in congestion. Also, the importance of various possible reasons for disliking congestion was requested. The outcomes show that time losses weigh most heavily (with an average score of 4.14 on a five-point scale), followed by uncertainty (3.61) and unpleasant driving conditions (3.52). The behaviour of fellow road users (2.78), and lastly the impact on the 'out-of-pocket' costs of road use (2.14), were considered the least important reasons for disliking congestion, and are ignored in the estimations below. Finally, 1.5 per cent of the respondents do not find congestion a general social problem (for instance, for environmental reasons, or because of the impact on the economy); 2.6 per cent have no opinion, and the rest find it an acceptable (16.4 per cent), unacceptable (63.3 per cent) or a highly unacceptable (16.3 per cent) problem. Clearly, then, morning peak road users do consider congestion a problem, both for private reasons and for social considerations.

Sub-model 1 attempts to investigate whether these judgements vary systematically across different groups of road users. Before turning to the results, it should be noted that for the other sub-models, the above variables were rescaled to dummies which take on the value of 1 if the respondent indicates an answer in one of the two highest categories. In order to maintain the compatibility of sub-model 1 with the other sub-models, therefore, binary probit analyses of these dummies were used for sub-model 1. Table 1 gives the most important outcomes.[4] In this table, a plus sign (minus sign) indicates a significant positive (negative) parameter estimate at the 0.1 level of significance; two and three pluses and minuses represent 0.05 and 0.01 levels of significance, respectively. Insignificance is reflected by no sign at all.

The extent to which respondents dislike driving in congestion (*DC34*) strongly depends on the severeness of congestion experienced (ln*CO/FR*: the natural logarithm of the ratio between travel time under congestion and free-flow travel time) and on the length of the trip (ln*Length*: the natural logarithm of trip length). The impacts of the other variables speak for themselves, and will be mentioned in subsection 4.5 if they are relevant for the recursive model.

The measures for overall statistical fit are of course not impressive, but at least indicate that the models, except the one for *DCD45*, do make sense. In the following sections, generally low measures for overall statistical fit will be reported. It is therefore good to stress here that the aim of the models is to identify the impact of certain variables on the dependent variables studied. For that purpose, individual parameter estimates and *t*-statistics are relevant, and these are therefore the statistics that will be discussed. Obviously, because of the unobserved heterogeneity among respondents, and in the light of the kind of questions studied in this paper, a high overall fit of the models simply cannot be expected.

[4] Because of missing values, the sample size for the various regressions is $N = 965$. The detailed regression results from this and some of the following sub-models are not given for reasons of space. They are available from the authors on request.

Table 1
Summary of Probit Estimates of Sub-Model 1: the Disutility of Congestion (N = 965)

	DC34	*DCT45*	*DCU45*	*DCD45*	*CGP34*
Inc3					++
HHS2		–			
HHS1		– – –	– –		
Purpb			+++		+
Purpm	+				
Morn23		– –			
Mornle1		–			
Educ3		+			
Educ4		++			
Occuent			+		
Age2		– –			
Age3		– – –			
Sametrip			–		
ln*CO/FR*	+++	++	+++		+++
ln*Length*	+++	+++	+++		
YKM3					++
Lik. rat. χ^2	73	67	91	30	52
sign.	0.000	0.000	0.000	0.272	0.002
pseudo R^2	0.07	0.06	0.07	0.02	0.06

Note: The following variables were included in the regressions but had no significant impact in any of the estimates: *Inc2, Compdk, Compy, Purpo, Educ2, Occuo, Gender, YC2, YC3, YKM2.*
Note: +/++/+++ (-/--/---) denote positive (negative) significant parameter estimates at the 0.1/0.05/0.01 levels of significance (two-sided *t*-test).

4.3 The willingness to pay for time gains

One of the key variables in theoretical work on the social feasibility of road pricing is the value of time. In the present survey, apart from asking for proxies for the theoretical determinants of this value of time according to equation (1), respondents were asked to indicate the minimum time gains they require for certain road prices, the answers to which imply a maximum willingness to pay (WTP) for time gains. An individual's WTP for time gains was subsequently calculated as the average of the implied WTPs for time gains for each WTP question.

Since respondents are put in a hypothetical situation, all sorts of biases and distortions can be expected, comparable to those arising with contingent valuation studies (see Mitchell and Carson, 1989). Not least, respondents may exhibit some sort of protest behaviour, in which case their disapproval of paying for time gains through the mechanism of road pricing as such would be reflected in lower WTP responses. Apart from that, the questions relate to time savings only, as opposed to time losses. For these reasons, the terminology of 'WTP for time gains', rather than the 'value of time', will be used below: the figures refer to the value of time savings that are non-voluntarily 'bought' through road pricing.

The problem of protest bidding — a maximum financial bid of 0 to express general protest against the instrument of road pricing as such — was minimised by asking for minimum time gains instead of maximum money bids. For various road prices, varying from DFl 1 to DFl 10,[5] respondents could either indicate the minimum time gain they require to be satisfied with road pricing, or that they found the fee mentioned prohibitively high. The equivalent protest bid of infinite time gains for a given road price was not actually given by any respondent. Moreover, the confidence in the WTP values obtained is further strengthened by the fact that the implied average valuation of time gains of about 40 per cent of net wages is well in line with other empirical work (see Small, 1992b, pp. 43-44; and, for the Dutch situation, HCG, 1990a and b).

For sub-model 2, the natural logarithm of the WTP for travel time gains (ln*WTP*) was regressed on a number of variables. A complication for this regression is the likely endogeneity of two particular variables, namely the length of the trip (ln*Length*) and the severity of congestion experienced (ln*CO/FR*). On the one hand, one would expect both variables to have a positive impact on the WTP for time gains, as both will have a positive impact on the marginal disutility of congestion. On the other hand, it can be imagined that people with a high value of time, and therewith a high WTP for time gains, will try to avoid long trips in severe congestion, for instance by choosing their work and/or residential location accordingly. This would lead to a negative correlation between these variables and the WTP for time gains. This was indeed found with an ordinary-least-squares (OLS) estimate of the WTP for time gains: both parameters were negative, with high significance.

An appropriate technique for handling such endogeneity problems is the 'two-stage-least-squares' (2SLS) procedure. In the first stage, the endogenous explanatory variables are regressed on a number of instruments, and the predicted values of these endogenous variables are subsequently used in the second stage. The resulting regression results are shown in Table 2. It is interesting to see that the parameter estimates for both ln*CO/FR* and ln*Length* then become insignificant. This means, in the first place, that the significantly negative effect on the WTP for time gains found with the OLS estimation was indeed due to the endogeneity of both variables. However, after correcting for this, the expected positive impact on WTP is not found. It might be argued that the *Morn* dummies ought to be endogenised for the same reason as ln*CO/FR* and ln*Length*. There were two reasons for

[5] The exchange rate of the Dutch guilder (DFl) is DFl 2.06 = 1 ECU.

Table 2
Second-Stage Results of 2SLS Regression for Sub-Model 2: the Natural Logarithm of the WTP for Time Gains (N = 965)

Variables	*β*	*t-value*	*sign. t*†	*Variables*	*β*	*t-value*	*sign. t*†
DC34	–0.00	–0.02	0.982	*Educ2*	0.06	0.52	0.603
DCT45	0.02	0.27	0.787	*Educ3*	0.15	1.37	0.173
DCU45	–0.02	–0.29	0.775	*Educ4*	0.22	1.26	0.208
DCD45	0.03	0.66	0.507				
*CGP34**	0.13	1.90	0.058	*Occuent*	0.13	1.46	0.144
				Occuo	0.18	1.38	0.169
Inc2	0.16	0.97	0.332				
*Inc3***	0.32	2.36	0.018	*Age2*	0.10	1.36	0.176
				Age3	0.05	0.75	0.453
Carpool	–0.04	–0.57	0.567				
				*Gender***	–0.15	–2.12	0.034
Compdk	0.09	1.22	0.225				
*Compy****	0.21	3.31	0.001	ln*CO/FR*[a]	0.03	0.02	0.982
				ln*Length*[a]	–0.12	–0.19	0.846
Purpb	–0.00	–0.00	0.997				
Purpm	0.03	0.35	0.725	*YC2*	–0.08	–0.94	0.347
Purpo	–0.10	–0.49	0.623	*YC3***	–0.19	–2.40	0.017
Morn23	0.18	1.23	0.219	*YKM2*	–0.06	–0.49	0.624
Mornle1	0.26	0.83	0.405	*YKM3*	0.00	0.01	0.993
				Constant	2.00	0.72	0.471

$R^2 = 0.10$

Note: *HHS2*, *HHS1* and *Sametrip* were not included in the second stage estimation for technical reasons: they had to be used as additional instrumental variables in th first stage. They were found to be insignificant in OLS estimations of WTP, both with and without ln*CO/FR* and ln*Length*.

† Two-sided test for significance of *t*
* Significant at the 0.10 level
** Significant at the 0.05 level
*** Significant at the 0.01 level
a Endogenous variable (predicted values were used in the second stage of the estimation)

not doing so. First, positive parameter estimates for *Mornle1* and *Morn23* could indicate an exogenous budget effect as well as an endogeneity problem. Second, and very practically, the fit of 2SLS estimates tends to decrease with the number of endogenised variables. Therefore, only those variables for which the endogeneity problem is evident and which are considered important variables in the estimation were endogenised.

In the second place, the other variables capturing the respondents' disutility of congestion, as discussed in the previous section, remain insignificant. This is the case for the general personal disutility of congestion (*DC34*), as well as for the three dummies

representing the most important reasons for disliking congestion. In contrast, the dummy capturing the extent to which the respondent sees congestion as a general problem (*CGP34*) is significant, showing that such respondents desire lower time gains for given road prices; presumably because they find that the policy serves a good general goal, apart from their own private interests.

The results, therefore, only partly validate equation (1). The effect of income on the WTP for time gains in the denominator of (1) is found, but the effect of the numerator (the marginal disutility of congestion) cannot be reproduced with the data set. A straightforward explanation is not easy to give. The insignificance of the *DC*-dummies might be due to the fact that the response to the various *DC*-questions is a subjective, rather than an objective variable. A more general explanation is that the income effect is by far the most dominant factor for the determination of the WTP for time gains according to (1). To mention a related example, it is not unlikely that the revealed WTP for travelling first-class by train or aeroplane may be much more strongly related to income than to the marginal utility of luxurious travelling. If the reduction in congestion during the morning peak is regarded as a move towards 'first-class' travelling, the analogy is complete.

In conclusion, when comparing the results with the prediction of equation (1), it appears that the WTP for time gains strongly depends on characteristics that are closely related to the financial side of road pricing: income, and the question of whether one will be compensated for paying the road price are strongly significant explanatory variables. The variables related to the personal disutility of congestion do not significantly affect the WTP.

4.4 Considered alternatives for current behaviour

The primary goal of road pricing, being the reduction, or even optimisation, of congestion, requires that some people be priced off the road at certain times and certain places. For the social and political feasibility of road pricing, it is important to see which alternatives such people consider after being priced off the road. The availability of relatively close or attractive alternatives may positively affect the individual's opinion on road pricing. Apart from that, it is important for governments to have an idea of the indirect impacts of road pricing before deciding whether to implement it. Therefore, respondents were asked to indicate the alternatives they would consider, should prohibitively high road prices make them change their behaviour. Multiple answers were allowed here, and Figure 2 shows that people indeed often consider various alternatives. The more drastic alternatives, such as searching for a new job or residence, or abandoning the trip, are seldom mentioned as the only alternative.

It is striking that the most frequently mentioned alternative is actually no alternative at all. This is shown by those people who indicated that, in spite of a (from their point of view) prohibitively high road price, they would still stick to their current behaviour. To some extent, these may be respondents who misunderstand the term 'prohibitive': the road price apparently is not prohibitive at all since it does not make them change their behaviour. Apart from that, however, these may be respondents with a highly inelastic demand for morning peak car travel, who find a certain road price prohibitively high for

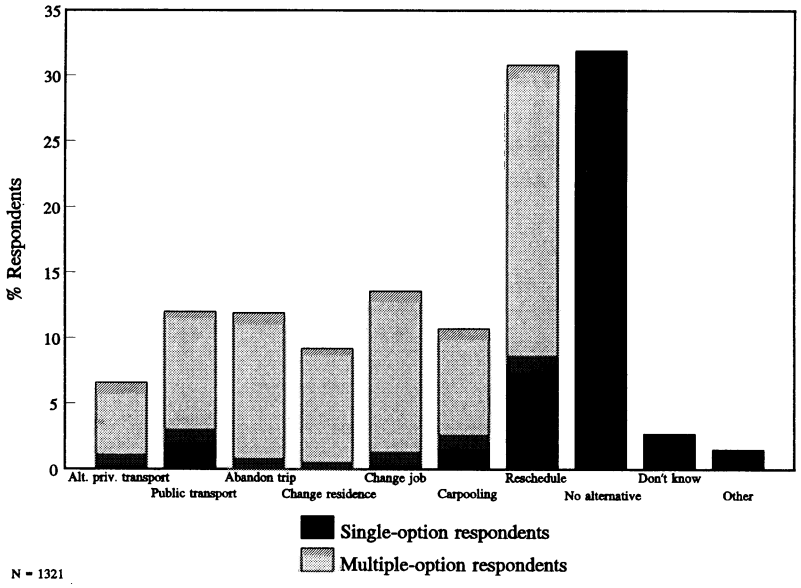

Figure 2
Considered Alternatives for Current Behaviour in the Morning Peak after Prohibitive Road Pricing

its unacceptable budget effect, but indeed see no alternative for their current behaviour. Finally, this high score may of course also be partly the result of a protest effect.

By far the most often mentioned true alternative is trip rescheduling, which is encouraging for the likeliness of congestion reduction through 'peak spreading', but slightly discouraging in so far as possible beneficial environmental side-effects of congestion charging by modal split effects are concerned.[6]

Sub-model 3 questions whether the reported alternatives vary systematically across different groups of road users. For that purpose, various probit estimates were performed (since multiple alternatives could be indicated, a multinomial probit analysis is not possible). Table 3 summarises the results for sub-model 3 using the same format as Table 1 for sub-model 1; the most relevant findings will be included in the discussion of the full recursive model in the next subsection.

[6] It is important to bear in mind that Figure 2 relates to the entire sample of respondents, including those who are likely to continue using the road with congestion pricing. It is therefore noteworthy that the shares of the various alternatives for the first 20 per cent of road users (when ordered according to increasing WTP for time gains so that those with the lowest WTP are selected) are quite close to the shares implied by Figure 2. Therefore, the considered alternatives for these respondents, who are more likely to leave the road system after road pricing than the other 80 per cent, are fairly accurately represented by Figure 2.

Table 3
*Summary of Probit Estimates of Sub-Model 3: Considered Alternatives for Current Behaviour (N = 936)**

	Alternative private transport	*Public transport*	*Abandon trip*	*Change residence*	*Change job*	*Car-pooling*	*Reschedule*	*No alternative*
	ALTOT	*ALTPT*	*ALTAT*	*ALTCR*	*ALTCJ*	*ALTCP*	*ALTR*	*NO-ALT*
ln*WTP*		+++		++	−−	++		
DCU45					−−−			+++
CGP34			++					
HHS2					+		−	
Carpool						+++		−−−
Compdk								++
Compy		−−		−−	−			++
Purpb					−−	−		
Purpm		−	+++				+++	
Mornle1		++					++	−−
Educ2	−							
Educ3	−		++			++		
Educ4	−−		++			+++	+++	−
Occuent		−			−			++
Occuo	+++	−−				−−		
Age2					−−−			
Age3	−−		+	−	−−−			
Gender	−−	−			+++			
Sametrip						++		−−
ln*PT/CO*		−−−	++					
ln*Length*	−−−	−		+++	+++			
YKM2		−−			+			
YKM3	−	−−−			+++	−−−		
lik. rat. χ^2	69	165	87	41	137	194	56	105
sign.	0.000	0.000	0.000	0.163	0.000	0.000	0.007	0.000
ps. R^2	0.17	0.22	0.09	0.06	0.17	0.29	0.05	0.09

* $N = 936$: due to inclusion of ln*PT/CO*, 29 cases had to be removed because of missing values.
Note: The following variables were included in the regressions but had no significant impact on any of the estimates: *DC34, DCT45, DCD45, Inc2, Inc3, HHS1, Purpo, Morn23, YC3. YC2* had a negative impact on the probability of changing job and residence, but is not included in the table because interpretation is lacking.

4.5. Opinions on road pricing

This subsection discusses the outcomes of the final sub-model 4, providing an exploratory analysis of road users' opinions on road pricing. A suitable statistical tool for analysing such data is the multinomial ordered probit model. This model does justice to the fact that the response can only take on discrete values, and also to the fact that the response is an ordinal (not a cardinal) variable. The analytical details of this model are given in Maddala (1983).

Table 4 gives the estimation results. By far the most significant factor is the WTP for time gains, which has the expected positive impact on the opinion on road pricing. Also, some of the variables that were seen to affect positively the WTP in Table 2 (subsection 4.3) remain significant in the present estimation: *Inc3* (the highest income group); *CGP34* (congestion as a general problem); and *Compy* (the expectation to be compensated); all with expected signs. Other variables strongly influencing the opinion on road pricing directly are ln*CO/FR* (the severeness of congestion experienced) and ln*Length* (trip length); also both with expected signs.

Again, as in sub-model 2, the various personal disutilities of congestion have no direct significant impact on the opinion on road pricing. However, the severity of congestion (ln*CO/FR*) and trip length (ln*Length*), which will also influence the marginal disutility of congestion — and additionally have a great impact on the various 'inconvenience of congestion dummies' according to Table 1 (subection 4.2) — are highly significant in the present estimation. This suggests that these variables may actually capture the disutility of congestion much better than the various DC-dummies, at least in the present estimation.

The direct and indirect impacts on the morning peak road users' opinions on road pricing can now be traced in the light of the full recursive model as given in Tables 1-4. Only the most outstanding results will be mentioned here. To begin with, the severity of congestion (ln*CO/FR*), apart from its direct effect on opinions, also has an indirect impact through the extent to which the respondent sees congestion as a general problem (*CGP34*). The direct impact of trip length (ln*Length*), in contrast, is somewhat dampened by its negative effect on the propensity to use public transport as an alternative. Nevertheless, these two variables, apparently, capture the personal disutility of congestion in the explanation of the opinion on road pricing.

Income (in particular the highest level *Inc3*) has a direct impact, and indirect impacts via *CGP34*, as well as via the WTP for time gains (ln*WTP*). The latter also holds for the expectation to be compensated (*Compy*). Here, however, the positive direct and indirect effects are slightly dampened because of the negative effect on the propensity to use public transport. These results strongly underline the importance that road users attach to the financial aspects of road pricing.

Segmentation by trip purpose, in particular when focusing on the two main groups of business (*Purpb*) and the reference group of commuters, hardly yields any significant results, except from slightly diverging preferences for alternatives.

The impact of frequency of morning peak road use (*Morn*-dummies) on the opinion on road pricing is only shown by a decreased probability of choosing the public transport alternative (*ALTPT*). Also the educational level (*Educ*-dummies) has no direct impact on

Table 4
Ordered Probit Regression Results for Sub-Model 4: Road Users' Opinions on Road Pricing (N = 965)

Variables	β	*t-value*	*sign. t*†	*Variables*	β	*t-value*	*sign. t*†
ln*WTP****	0.55	9.49	0.000	*Occuent*	–0.11	–0.84	0.400
				Occuo	–0.00	–0.02	0.983
DC34	–0.04	–0.41	0.682				
DCT45	–0.14	–1.40	0.162	*Age2*	–0.05	–0.47	0.641
DCU45	0.02	0.23	0.818	*Age3*	0.11	0.90	0.369
DCD45	0.06	0.82	0.411				
*CGP34****	0.32	3.00	0.003	*Gender*	0.02	0.20	0.838
Inc2	0.18	1.02	0.309	*Sametrip*	–0.13	–1.07	0.285
*Inc3***	0.39	2.11	0.035				
				ln*COIFR****	0.56	2.93	0.003
HHS2	–0.13	–1.43	0.152	ln*Length***	0.15	2.01	0.044
*HHS1***	0.29	2.40	0.016				
				ALTOT	–0.11	–0.66	0.512
Carpool	–0.10	–0.82	0.414	*ALTPT****	0.31	2.63	0.009
				ALTAT	0.03	0.27	0.786
Compdk	0.11	1.09	0.276	*ALTCR*	0.02	0.19	0.852
*Compy***	0.22	2.37	0.018	*ALTCJ*	–0.03	–0.30	0.763
				*ALTCP***	0.23	1.83	0.067
Purpb	0.10	0.71	0.480	*ALTR*	0.08	0.99	0.320
*Purpm**	0.19	1.79	0.074	*ALTO*	–0.17	–0.81	0.417
*Purpo**	0.50	1.70	0.089				
				YC2	–0.18	–1.41	0.158
Morn23	0.10	1.06	0.290	*YC3*	–0.17	–1.30	0.193
Mornle1	–0.07	–0.56	0.577				
				YKM2	–0.10	–0.74	0.459
Educ2	–0.02	–0.11	0.914	*YKM3*	–0.04	–0.27	0.786
Educ3	0.18	1.16	0.246				
Educ4	0.24	1.45	0.149				

Measures of fit:		Constants:			
likelihood ratio χ^2 (sign.)	224 (0.0000)	α_1***	2.19	4.84	0.000
–2 log likelihood full model	2255	α_2***	3.05	6.71	0.000
–2 log likelihood restricted model	2479	α_3***	4.00	8.66	0.000
pseudo R^2	0.09				

† Two-sided test for significance of *t*
* Significant at the 0.10 level
** Significant at the 0.05 level
*** Significant at the 0.01 level

opinion, but a positive indirect impact through the increased probability of choosing carpooling as an alternative (*ALTCP*). Entrepreneurs (*Occuent*), as opposed to the reference group of full-time employees, have no significantly different opinions on road pricing, but indirectly have a more negative opinion because of their lower propensity to choose public transport. Morning peak road users with 'stable' travel behaviour (*Sametrip*) only indirectly have a more positive opinion on road pricing because of their larger propensity to carpool.

Age has no significant effect at all; and female respondents are indirectly more opposed to road pricing because of their lower WTP and lower propensity to choose the public transport alternative.

People who drive more kilometres per year by car (especially *YKM3*) are more likely to have a positive opinion on road pricing because of its effect on the extent to which congestion is seen as a general problem. However, a compensating negative effect is that these respondents are less likely to use public transport or to carpool after the introduction of road pricing. No direct impact on opinion was found. Respondents who have had a car at their disposal for a longer period (*YC3*) are only indirectly more opposed to road pricing by a lower WTP.

Finally, the extent to which respondents see congestion as a general problem (*CGP34*) has a positive impact on their opinion on road pricing, both directly, and also indirectly because of a higher WTP for time gains. This, in turn, has a direct positive impact, as well as an indirect positive impact through increased propensities to carpool and to use public transport when road prices are prohibitively high.

4.6 The effect of compensation for road prices

Before turning to the allocation of tax revenues, a few words should be said about the effect of compensation for road prices. It has become clear that respondents who expect to be compensated have a higher WTP for time gains and a more positive opinion on road pricing (which is not surprising). However, the estimations in subsection 4.4 demonstrated that these people, equally naturally, are not inclined to change their behaviour. On the one hand, it could be argued that this may frustrate the effectiveness of road pricing. To some extent, this is true. However, it should not be forgotten that, from the efficiency point of view, this need not be a problem.

The employers' apparent benefits of having these employees travelling by car, in addition to their own personal benefits, may often put these employees on the 'left-hand side of the demand curve'. In that case, they should indeed continue to use the road after road pricing, as they are drivers with a relatively high social benefit of road use. Where this is not the case, employers may be expected to change their travel cost compensation programmes after the implementation of road pricing. This, then, may eventually lead to some of these people being priced off the road. Therefore, compensation for road prices *per se* causes no fundamental problem for the efficiency of road pricing. Nevertheless, this issue, as well as comparable matters of, for instance, any tax deductibility of road prices, should be carefully investigated before implementing road pricing. These topics, however, are not of primary concern in the present study.

5. The Allocation of Revenues

The allocation of revenues raised with road pricing can be an important means of increasing its social feasibility (Goodwin, 1989; Jones, 1991; Small, 1992a). Also, the results in the previous section indicate that road users are mainly concerned with the redistributional impacts of road pricing; this is in sharp contrast with the academics' main focus on the efficiency of road use. The overwhelming majority of respondents who state that their opinion on road pricing is dependent on the allocation of revenues (83 per cent) is therefore not surprising. Moreover, this fact should be taken very seriously in the formulation of road pricing schemes, as it may turn out to be one of the most crucial success factors for the social acceptance of road pricing.

One of the questions was directly related to this issue of revenue allocation. Respondents were asked to indicate their opinion on a number of possible allocations on a five-point scale, varying from a 'very bad allocation of revenues' (1) to a 'very good allocation of revenues' (5). Figure 3 summarises the results, by showing both the average and median scores for each alternative mentioned (the latter reflects the opinion of the 'median voter', which is the decisive opinion in simple models of democratic decision-making; see Atkinson and Stiglitz, 1980, ch. 10).

After ordering the various alternatives according to decreasing popularity in Figure 3, a clear message appears. As expected, the further the allocation is from the direct interests of the road users, the less support it receives. It is interesting to see that the theoretically most elegant allocation of congestion pricing revenues, namely to the provision of road infrastructure capacity,[7] receives the highest average score. Given the second priority of reductions in fixed annual vehicle ownership taxes, it is clear that road users are relatively sympathetic towards such 'variabilisation' of road charges: the median opinion for both allocations is 'good'. Since a certain proportion of Dutch road investments is now financed with revenues from vehicle taxation, such variabilisation may offer the government an important tool to overcome, at least in part, the social resistance to road pricing. A shift from fuel taxes towards congestion pricing seems less attractive; not only because fuel tax reductions receive slightly less support than vehicle tax reductions, but also because fuel tax reductions will (most probably) stimulate road use outside peak hours, thus giving rise to additional environmental externalities.

Turning to the less popular allocations, it is noteworthy that investments in carpool facilities are seen as a less desirable allocation than public transport. Within the area of public transport, investments are considered a more attractive allocation than subsidies in general. This could be related to the currently insufficient capacity of public transport (notably rail) at peak hours in the Randstad area. General purposes again receive less support than transport-related purposes, with general tax reductions being slightly preferred to general public investments, and with the lowest scores obtained by the most general goal specified, namely the overall government budget.

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[7] Under certain assumptions, in particular constant returns to scale in user cost and capacity construction, it can be shown that the revenues of optimal congestion pricing are just sufficient to cover the cost of optimal capacity supply (Mohring and Harwitz, 1962).

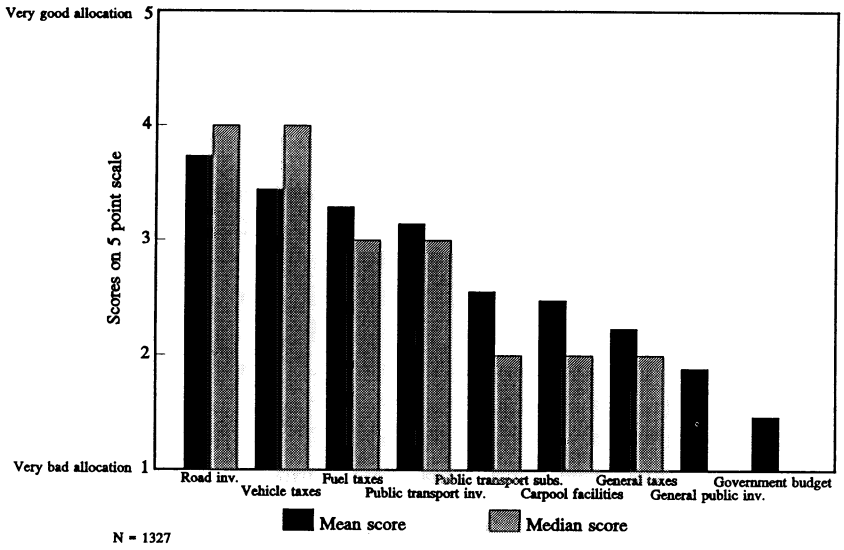

Figure 3
Morning Peak Road Users' Opinions on Various Allocations of Revenues Raised with Road Pricing

In order to obtain some insight into the factors that determine an individual's opinion on the various possible allocations of revenues, the scores were regressed with an ordered probit model. Because the outcomes were reasonably straightforward, and in order to save space, the results are not presented in tabular form. Two important conclusions resulting from these estimations are: (a) that lower income groups are more in favour of general and fuel tax reductions, and less sympathetic towards road investments, which is consistent with the earlier findings on the importance of financial considerations, especially for lower income groups; and (b) that respondents who expect to be compensated for the road price are, as expected, less positive about reductions in vehicle and fuel taxes (for which they are often compensated already), and more positive about allocations that may yield them additional benefits, such as road investments and public transport subsidies.

6. Conclusion

Road pricing, although being theoretically the first-best economic solution to reduce excessive road traffic congestion, has so far not received much support outside the academic world. The foregoing analysis addressed this issue of limited social feasibility by analysing and discussing the results of a questionnaire that was held among morning peak road users in the Randstad area.

Road pricing was found to be not completely socially unacceptable. In the first place, people were able to express some positive valuation of time gains through road pricing, with an average of nearly DFl 11 per hour. Second, about 25 per cent of the respondents indicated that they found road pricing a good idea, although most of these admitted to be reluctant to pay for morning peak road use.

A recursive analysis revealed a number of factors determining the disutility attached to congestion, the willingness to pay for time gains, the considered alternatives for current behaviour, and the opinions on road pricing. As anticipated, it is mainly the financial transfers resulting from road pricing, and therewith its redistributive impacts, that determine road users' opinions on road pricing. This is in sharp contrast with the traditional economists' focus on allocative efficiency, for which it is only the sum of net benefits of road pricing — not the distribution — that counts. The analysis revealed that income (and in particular the narrowly related WTP for time gains) as well as the expectation of being compensated for road prices, dominate road users' opinions on road pricing. In addition, respondents who suffer from severe congestion, and (partly for that reason) see congestion as a general problem, do have more positive attitudes, both in terms of higher WTPs for time gains, and in terms of more positive opinions on road pricing. An implication is that the introduction of road pricing is likely to provoke less resistance when it is made explicitly clear to the public that it serves a good and important social goal, and if road pricing is to be restricted to areas suffering from serious congestion.

The regressive impact of road pricing, which is often mentioned as a potential obstacle for its introduction, was clearly reflected in the various sub-models. It is, however, questionable whether this really provides a strong case against road pricing, as it has to be decided whether the progressive incidence of welfare losses from unregulated congestion provides a sound basis for leaving this inefficiency in existence. However, the allocation of revenues can be used to minimise resistance on income distribution grounds. A large majority of respondents found the allocation of revenues of importance. For theoretical reasons, and given the response to the questions relating to various alternative allocations, it seems preferable to use part of the revenues from road pricing for replacing the fixed vehicle ownership taxes currently used to finance the construction of additional road infrastructure. The regressive incidence of road pricing itself can then be dampened by relatively larger reductions in taxes for smaller and cheaper vehicles, providing lower income groups with a real opportunity to remain relatively well off. This, in turn, may prove to have a positive impact on the average fuel efficiency of the car fleet — although such a redefinition of the vehicle ownership tax structure may of course include additional benefits for cleaner cars *per se*. It may also take away potential feelings of injustice concerning road users who are having their road prices and other expenditures on road use compensated. The re-allocation of revenues outside the transport sector does not seem a good idea, and is likely to stimulate existing prejudices of road users as being one of the government's favourite 'cash cows' (witness also many 'other remarks' made on the returned questionnaires).

The most popular behavioural response to congestion pricing, after the no-alternative option, is rescheduling. In the long run, additional positive impacts on congestion can be

expected because road pricing stimulates the search for new jobs and residences. Also, alternatives such as public transport (strongly dependent on availability), carpooling (especially for road users making the same trip each morning), and even trip abandonment, are frequently mentioned. This suggests that road pricing surely need not be frustrated by a completely inelastic demand for road transport in the morning peak.

Appendix
List of variables

Variable	Description
Opinion	4-point scale measuring the opinion on road pricing, with the following categories: "bad idea"; "moderate idea"; "of course I do not feel like paying road charges but still I think it is a good idea"; and "good idea".
ln*WTP*	The natural logarithm of the average of implied maximum WTPs for time gains.
DC	Disutility of congestion: 4-point scale measuring the extent to which the respondent dislikes road use in congested situations.
DC34	Dummy variable; takes on the value of 1 if *DC* = 3 or 4, and 0 otherwise.
DCT	5-point scale measuring the extent to which the respondent dislikes congestion because of time losses.
DCT45	Dummy variable; takes on the value of 1 if *DCT* = 4 or 5, and 0 otherwise.
DCU	5-point scale measuring the extent to which the respondent dislikes congestion because of uncertainty.
DCU45	Dummy variable; takes on the value of 1 if *DCU* = 4 or 5, and 0 otherwise.
DCD	5-point scale measuring the extent to which the respondent dislikes congestion because of driving conditions.
DCD45	Dummy variable; takes on the value of 1 if *DCD* = 4 or 5, and 0 otherwise.
CGP	Congestion as a general social problem; 4-point scale measuring the extent to which the respondent thinks congestion is a general social problem, for instance for environmental reasons or the impact on the economy.
CGP34	Dummy variable; takes on the value of 1 if *CGP* = 3 or 4, and 0 otherwise.
Income	Monthly net household income
Inc1	Dummy variable (reference group); takes on the value of 1 if *Income* ≤ Dfl 2500.
Inc2	Dummy variable; takes on the value of 1 if Dfl 2500 < *Income* ≤ Dfl 4500.
Inc3	Dummy variable; takes on the value of 1 if *Income* > Dfl 4500.
HHS	Household size.
HHSR	Dummy variable (reference group); takes on the value of 1 if *HHS* > 2.
HHS2	Dummy variable; takes on the value of 1 if *HHS* = 2.
HHS1	Dummy variable; takes on the value of 1 if *HHS* = 1.
Carpool	Dummy variable; takes on the value of 1 if the respondent drives on average with more than 1 person in the morning peak when using the car, and 0 otherwise.

Compensation	Does the respondent expect to be compensated for a road price?
Compn	Dummy variable (reference group); takes on the value of 1 if *Compensation* = no.
Compdk	Dummy variable; takes on the value of 1 if *Compensation* = don't know.
Compy	Dummy variable; takes on the value of 1 if *Compensation* = yes.
Purpose	Trip purpose when travelling on the road during morning peak hour.
Purpc	Dummy variable (reference group); takes on the value of 1 if *Purpose* = commuting.
Purpb	Dummy variable; takes on the value of 1 if *Purpose* = business.
Purpm	Dummy variable; takes on the value of 1 if *Purpose* = Multi-purpose — usually business and commuting.
Purpo	Dummy variable; takes on the value of 1 if *Purpose* = other.
Morning	Average number of mornings per week that the respondent drives in congestion.
Morno3	Dummy variable (reference group); takes on the value of 1 if *Morning* > 3.
Morn23	Dummy variable; takes on the value of 1 if *Morning* = 2 or 3.
Mornle1	Dummy variable; takes on the value of 1 if *Morning* ≤ 1.
Education	Highest educational level obtained.
Educ1	Dummy variable (reference group); takes on the value of 1 if *Education* = Basis, LBO, LAVO or MAVO (primary school, lower vocational, and lower and middle level of high school).
Educ2	Dummy variable; takes on the value of 1 if *Education* = HAVO, VWO, or MBO (higher levels of high school and middle level of vocational education).
Educ3	Dummy variable; takes on the value of 1 if *Education* = HBO (various Polytechnics and higher level of vocational education).
Educ4	Dummy variable; takes on the value of 1 if *Education* = University.
Occupation	Main occupation.
Occft	Dummy variable (reference group); takes on the value of 1 if *Occupation* = full-time employed.
Occuent	Dummy variable; takes on the value of 1 if *Occupation* = entrepreneur.
Occuo	Dummy variable; takes on the value of 1 if *Occupation* = other (part-time worker, unemployed, housewife/man, retired etc.)
Age	Age (in years).
Age1	Dummy variable (reference group); takes on the value of 1 if *Age* ≤ 35.
Age2	Dummy variable; takes on the value of 1 if 35 < *Age* ≤ 45.
Age3	Dummy variable; takes on the value of 1 if *Age* > 45.
Gender	Dummy variable; takes on the value of 1 if the respondent is female, and 0 if male.
Sametrip	Dummy variable; takes on the value of 1 if the respondent makes the same trip more than 50% of the time (time, origin-destination, etc.) when travelling by car in the morning peak, and 0 otherwise.
ln*CO/FR**	The natural logarithm of the ratio between travel time under congestion and free-flow travel time.
ln*PT/CO**	The natural logarithm of the ratio between travel time with public transport and by car under congestion.
ln*Length**	The natural logarithm of the travel distance by road.

* ln*Length*, ln*CO/FR* and ln*PT/CO* hold for the average trip if *Sametrip* = 1, and for the specific trip made when receiving the questionnaire otherwise.

Alternative	Which alternative does the respondent consider in case of prohibitively high road pricing?
NO-ALT	Dummy variable (reference group); takes on the value of 1 if the respondent sees on alternative to current behaviour in case of prohibitively high road prices.
ALTOT	Dummy variable; takes on the value of 1 if *Alternative* = other private transport.
ALTPT	Dummy variable; takes on the value of 1 if *Alternative* = public transport.
ALTAT	Dummy variable; takes on the value of 1 if *Alternative* = trip abandonment.
ALTCR	Dummy variable; takes on the value of 1 if *Alternative* = look for another residence.
ALTCJ	Dummy variable; takes on the value of 1 if *Alternative* = look for another job.
ALTCP	Dummy variable; takes on the value of 1 if *Alternative* = carpool (more often).
ALTR	Dummy variable; takes on the value of 1 if *Alternative* = reschedule the trip.
ALTO	Dummy variable; takes on the value of 1 if *Alternative* = other.
YC	The number of years the respondent has a car at his or her disposal.
YC1	Dummy variable (reference group); takes on the value of 1 if $YC \leq 5$.
YC2	Dummy variable; takes on the value of 1 if $5 < YC \leq 10$.
YC3	Dummy variable; takes on the value of 1 if $YC > 10$.
YKM	The number of kilometres the respondent drives him(her)self in a car.
YKM1	Dummy variable (reference group); takes on the value of 1 if $YKM \leq 20{,}000$.
YKM2	Dummy variable; takes on the value of 1 if $20{,}000 < YKM \leq 40{,}000$.
YKM3	Dummy variable; takes on the value of 1 if $YKM > 40{,}000$.

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